PRE-FAILURE DIAGNOSIS OF SUBSTATION ELECTRICALE QUIPMENT UNDER ICING CONDITION AND PREVENTIVE TECHNIQUES

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Abstract: **The preventive and de-icing technique for the de-icing of substation electrical equipment home and abroad and its application effectiveness were introduced. In connection with the experience of applying UV daytime camera in the detection of corona occurring on the electrical equipment and flashover due to the development of the corona, pre-failure diagnosis of substation electrical equipment undericing cond ition and preventive techniques were raised in order to prevent flashover from happening.**

1. INTRODUCTION

In the snowy weather, the accident types of transform equipment are mainly reflected as pollution flashover and icing flashover in the high voltage electrical equipments' external insulation. The pollution flashover of icing insulator is that as the electric porcelain insulator are polluted, the conductance of insulator's polluted surface is increasing and so is the leakage current during the early of icing and ice-melting period. Then the particial discharge happens and it may become arc flashover under appropriate conditions.

Icing flashover is that the ice-coated insulators' shed cluster is bridged by icicle, resulted in lower flashover voltage of external insulation. Especially the uneven ice appearing on the surface of insulators, due to the uneven distribution of longitudinal potential. It may cause the flashover of equipment's external insulation easily.

According to statistics, the current resarch and measure of anti-icing, de-icing and ice (snow) disaster prevention are mainly focus on transmission lines, while little about substation electrical equipments home and abroad.

2. RESULTS

The monitoring Technology of icing substation electrical equipment are Visual method and UV detection technology. By observing and listening to the sound of discharge, combined with operating experience, we can judge how severe the discharging of icing electrical equipment is, and decide whether to deal with it depend on the situation. But this method has large error and randomness, leading to a false judgement.

Anti-icing technology of substation electrical equipment contains installing adding silicon rubber creepage extenders and coated RTV hydrophobic coatings. Installing the silicone rubber adding creepage extends can improve the anti-pollution flashover ability of the electrical equipment, while blocking the ice bridge. And installing shed cluster of large external diameter on the surface of the insulator can increase the leakage distance, which is a effective measure of creepage adjustment for substation. Coating RTV hydrophobic coating can effectively alleviate the icing and the wet flashover in freezing or pollution flashover in de-icing.

De-icing technology for substation electrical equipment includes use of steam for de-icing the operating substation isolating switch and manual de-icing. The techniques based on steam de-icing, is the improvement of hot-water de-icing method. This technique is widely used in Quebec, Canada, mainly for Hydrants, water pipes, ground and windows. While it stays in experimental stage for electrical equipment de-icing. And we adopt the manual de-icing method by using insulated stick to knock off the surface icicle at home.

3. CONCLUSION

For the pre-failure diagonosis and preventive techniques of substation's ice storm, we should focus on preventing the icing flashover of electrical equipment in substation.

UV detection is good for the pre-failure diagonosis of substation's ice storm, and it is worth promoting.

Meanwhile it is an effective method to prevent the icing flashover ofelectrical equipment in substation by installing adding creepage extenders and coating RTV paint.

Before the surface icicle of substation electrical equipment completely bridged, we can easily use manual de-icing method. However operational procedures shall be established. When the icicle completely through, based on the consequence of UV detection, we should determine whether de-icing without electricity.

For heavy icing substation, we can take measures to reduce loss, such as transfering load and quiting hot reserve equipment, etc.

4. REFERENCES

[1] Y. Liu, X. Sun, J. Liu, "A theoretical calculation model for flashover voltage of ice-coated and polluted insulators", Power System Technology, Vol. 29, No. 14, 2005, pp 73-76.

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***Abstract*—The preventive and de-icing technique for the de-icing of substation electrical equipment home and abroad and its application effectiveness were introduced. In connection with the experience of applying UV daytime camera in the detection of corona occurring on the electrical equipment and flashover due to the development of the corona, pre-failure diagnosis of substation electrical equipment undericing cond ition and preventive techniques were raised in order to prevent flashover from happening.**

Keywords-substation; electrical equipment; UV detection; icing; pre-failure diagnosis

I. INTRODUCTION

In the snowy weather, the accident types of transform equipment are mainly reflected as pollution flashover and icing flashover in the high voltage electrical equipments' external insulation. The pollution flashover of icing insulator is that as the electric porcelain insulator are polluted, the conductance of insulator's polluted surface is increasing and so is the leakage current during the early of icing and ice-melting period. Then the particial discharge happens and it may become arc flashover under appropriate conditions.

Icing flashover is that the ice-coated insulators' shed cluster is bridged by icicle, resulted in lower flashover voltage of external insulation. Especially the uneven ice appearing on the surface of insulators, due to the uneven distribution of longitudinal potential. It may cause the flashover of equipment's external insulation easily. The icing flashover is shown in Fig.1 and Fig.2.

The flashover of icing electrical equipment's external insulator often occurrs in the bus pillar (suspension) insulators, knife switch post insulator, CT and equipment with short creeping distance or unreasonable umbrella configuration, easpecially the flashover of 500kV equipment's external insulation happens much more easily than that of 220kV. Because under icing condition, the unit length of 500kV equipment's external insulation suffers higher voltage than that of 220kV.

Figure 1: The surface icing state of 5012 Phase B, 500kV YuXian Substation.

Figure 2: The surface accidental situation of 5013 Phase C, 500kV YuXian Substation.

According to statistics, the current resarch and measure of anti-icing, de-icing and ice (snow) disaster prevention are mainly focus on transmission lines, while little about substation electrical equipments home and abroad.

II. THE MONITORING TECHNOLOGY OF ICING SUBSTATION ELECTRICAL EQUIPMENT

A. Visual Method

By observing and listening to the sound of discharge, combined with operating experience, we can judge how severe the discharging of icing electrical equipment is, and decide whether to deal with it depend on the situation. But this method has large error and randomness, leading to a false judgement.

B. *UV Detection Technology*

In the 2005 and 2008 ice storm, we had applied UV detection technique to detect the corona discharging of substation icing electrical equipment. It had a significant effect.

On Feb. 7, 2005, by detecting the corona discharging of operating icing electrical equipment, they found the upper corona was intense on the 50311 knife switch's 3-phase post porcelain insulator 500kV Xiaogan in time. Instantaneous discharge has shorted the insulator, it was in the critical state of flashover.

On Jan 18, 2008, in the process of UV detecting Phoenix Hill Substation, they found that the post porcelain insulators at the second 500kV line Fengci traps were abnormal. The surface of upper post insulator was discharging continuously and the maximum discharging volume was more than 10,000 photons per second. Then they cut off the power and cleaned it immediately, due to dealt with it in time and used the appropriate measures, a pollution flashover accident was avoided.

On Jan.27 , 2008, the post porcelain insulator(two stacked) of 220kV knife switch in 500kV Xiaogan Substation, along the windward side, the insulators' suface were connected by snow. The knife switch post insulator formed 4 creeping sections (dry area) along the surface. The arc seemed to be yellow and dense. By UV detection, the corona discharge form was intense and continuous, 4 dry areas discharged at the same time. Along the insulator surface, the air that within the dry arc distance began to ionize and almost breakdown.

On the same day, the 500kV II-bus overhang insulators which was level arranged in Xiaogan 500kV substation creeped seriosly, especially phase A. All the 30 bus insulators were anti-dust. The creeping phenomenon of Phase A conductor at grading rings along the side of insulator was serious. The arc stretched and 9 insulators were short circuit. The arc was intermittent explosive form.

III. ANTI-ICING TECHNOLOGY OF SUBSTATION ELECTRICAL EQUIPMENT

A. *Installing Adding Silicon Rubber Creepage Extenders*

Installing the silicone rubber adding creepage extends can improve the anti-pollution flashover ability of the electrical equipment, while blocking the ice bridge. And installing shed cluster of large external diameter on the surface of the insulator can increase the leakage distance, which is a effective measure of creepage adjustment for substation.

Silicone rubber shed cluster is adhesive on the porcelain extenders. It can increase the creepage distance and improve electrical characteristics and structure of the surface shape. Also the shed cluster and porcelain extenders form the composited insulating structer, and its performance is far superior to pure porcelain insulation. After installing the adding creepage extenders on porcelain extenders, the voltage of pollution flashover can increase 10%～30%. It can prevent the pollution flashover accident of transmission equipment.

Installing secion the adding creepage extenders of insulator can prevent icicle connecion and icing flashover.

(1)Silicone rubber shed cluster has good hydrophobicity and hydrophobic migration. The surface energy silicone rubber is low , and water form on silicone rubber surface or pollution layer surface is droplets . So pollution layer is difficult to get wet. Thus it can improve the situation of composited insulating medium's surface. It is not easy for pollution layer to form continious water film(conductive layer). The leakage current of insulator's surface which has installed adding creepage extenders is decreasing. It can improve the characteristic of pollution flashover.

(2)Uniform voltage distribution. Since silicone rubber is highly hydrophobic and difficult to form a continuous conductive layer, so it is impossible to appear that voltage is unevenly distributed.

(3)High pollution flashover voltage. Installation of adding creepage extenders, extending the arc channel.

(4)Large effect of resisting arc. We can prevent the insulator's surface icing flashover accident in the process of de-icing, by using large silicone rubber diameter to cut off the "sewage bridge".

After using adding creepage extenders in Phoenix Hill and Yuxian 500kVsubstation, the effective of anti-icing flashover is remarkble, there is no icicle connection between shed cluster. (The maximum length of measured icicle is 10cm)

B. *Coated RTV Hydrophobic Coatings*

Coating RTV hydrophobic coating can effectively alleviate the icing and the wet flashover in freezing or pollution flashover in de-icing.

RTV coating has good hydrophobicity and hydrophobic migration, so that the pollution of insulator's surface also has hydrophobicity, it can improve the level of insulator's pollution performance. This is because the interaction force between non-polar solid molecules and water molecules (attraction force) is less than the cohesion force between water molecules. At the same time, RTV contains a large number of free ions silicone oligomers and small molecular groups, these materials are hydrophobic, when the RTV surface are polluted, the free state hydrophobic material within RTV gradually spread to the polluted surface, so that the pollution layer is also hydrophobic. In the fog, dew, drizzle and other wet weather conditions, polluted layer is difficult to get wet, Even if the absorption of water, it is only a discontinuous form of small droplets instead of a continuous water film. It represses the genenration and development of leakage current and partial arc, significantly improved the anti-pollution voltage of insulator.

(1) *Long effective time and high reliability.*

As the survey show, if the electrical equipment were coated long-term effective RTV coating, even without any anti flashover professional handling (including cleaning and washing, etc.) in 5 years, its' RTV coating layer still has a good hydrophobicity and hydrophobic migration . The RTV coating layer which has operated more than 5 years (up to 15 years), can be re-coated without cleaning, restoring every electrical characteristic to the new coating state, and continue working on for a long term.

(2) *Good adaptability*

RTV coating layer itself can be widely adapted to a variety of natural and industrial contamination. Meanwhile, it can keep good pollution performance in a variety of pollution sources for a long term.

However the effective useful life of RTV anti-pollution flashover coating should be noticed. Operation and maintenance stuff should examine the RTV regularly. If they found the aging of skin, re-coating work should be done immediately.

It has a history of decades for the study on RTV application in power system. USA Pacific Gas and Electric Company coated with 0.51mm thick RTV silicone rubber coating on the porcelain insulator surface of 66kV operating transmission line under the heavy polluted condition. After 6 years, we discover that though there is a layer of dirt on the porcelain insulator's surface, its hydrophobic insulation is still very high.

In the recent 10 years, RTV anti-pollution flashover coating have been widely used for the external insulation of primary high voltage equipment in power system. It has improved the external insulation level of the electrical equipments which are in the heavy pollution and bad weather condition area.

IV. DE-ICING TECHNOLOGY FOR SUBSTATION ELECTRICAL EQUIPMENT

A. Use of Steam for De-icing the Operating Substation Isolating Switch

The techniques based on steam de-icing, is the improvement of hot-water de-icing method. This technique is widely used in Quebec, Canada, mainly for Hydrants, water pipes, ground and windows. While it stays in experimental stage for electrical equipment de-icing.

(1) *Use of steam for de-icing the equipments without*

Using a portable steam generator , which can generate 49kg(110 1bs), 3bars(45psi) pressure steam in a hour, to de-icing a full single phase 145kV isolating switch with multiple iced connections. The experiment lasts less than 2minutes in order to turn on the isolating switch.

(2)*Use of steam for de-icing the equipments with electricity*

The experiment shows that after using the steam de-icing, water can clean all the suface pollutant of isolating switch, thus it can decrease the leakage current and prevent flashover. When 9 de-icing experiments have been done, there is no flashover occurs, each de-icing process cost 5 minutes.

B. Manual De-icing

So far, we adopt the manual de-icing method by using insulated stick to knock off the surface icicle at home.

V. CONCLUTION

(1) For the pre-failure diagonosis and preventive techniques of substation's ice storm, we should focus on preventing the icing flashover of electrical equipment in substation.

(2) UV detection is good for the pre-failure diagonosis of substation's ice storm, and it is worth promoting.

(3) Meanwhile it is an effective method to prevent the icing flashover ofelectrical equipment in substation by installing adding creepage extenders and coating RTV paint.

(4) Before the surface icicle of substation electrical equipment completely bridged, we can easily use manual de-icing method. However operational procedures shall be established. When the icicle completely through, based on the consequence of UV detection, we should determine whether de-icing without electricity.

(5) For heavy icing substation, we can take measures to reduce loss, such as transfering load and quiting hot reserve equipment, etc.

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